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FORTIFICATION

By

Captain H. B. Sauerman

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H. B. Sauerman

EXTRACTS OF LETTERS AND REVIEWS.

From a Colonel of Engineers U. S. Army.

"I have received the advance copy of your paper on "Fortification" and have read it with a great deal of interest. I think you have covered the subject well and I congratulate you."

From an Instructor U.S. Military Academy at West Point.

"The object which you outline in your preface has been admirably accomplished and the subject handled in a thorough, unconventional and interesting way. The cuts are excellent."

From a Major of Engineers U.S. Army.

"You will see from the attached that your work on "Fortification" has been of assistance to the Board of Engineer Troops.

Please accept my congratulations on the result you accomplished in putting this subject in a shape which is different from the usual text-book style and, which "it strikes me, will appeal to the military student."

From a Major of Engineers U.S. Army.

"The emphasis placed on concealment is not too strong.
The artillery considerations are well stated.
The Cavalry scope is set down simply and well.
The discussion of overhead cover and splinter proofs is well done, and the information is fresh as applied to European warfare."

From a Major of Engineers U.S. Army.

"I congratulate you on having produced an up-to-date treatment of the subject. The illustrations are well selected to bring out the important features."

From an Officer - The Office of the Chief of Staff.

"I congratulate you on what seems to me a very valuable condensation of up-to-date knowledge on the subject of fortification."

From an Instructor of a Military Academy.

"The advantage you take of the enormous development of trench warfare in Europe makes your book the latest authority, besides which and most important it is written to read - not to solve."

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PREFACE

Almost all military engineering work can be considered an aid to tactics. Fortification is one of the most important branches of military engineering and one of the most important aids to tactics. The civilian engineers of the nation can well take care of the construction, reconstruction, demolition and other engineering work in time of war, but they will not be of much help in fortification work unless they gain a knowledge of tactics. On the other hand, the militia officer with a knowledge of tactics must have some knowledge of the underlying principles of field fortification construction in order to use fortification to the fullest extent, and to the best advantage in solving tactical problems.

The object of this short work on Fortification is:

1. To impress upon the civilian engineer and the militia officer the importance of fortification.
2. To show him how to analyze some of the problems and situations of field fortification.
3. To give him some of the main underlying principles of field fortification.
4. To create a desire for further study.
5. To show the practical application of fortification in a modern war.

The author takes this opportunity to gratefully acknowledge the able assistance, advice and encouragement that he received from Major C. W. Otwell, Corps of Engineers, U. S. A., and from Major M. J. McDonough, Corps of Engineers, U. S. A. With the instructions and assistance furnished by these very able officers, many of our militia engineers have gained a knowledge which will be of great value to our nation in time of war.

In conjunction with this work on fortification the author recommends the following publications for study:

Engineer Field Manual.
Field Service Regulations.
Infantry Drill Regulations.
Cavalry Drill Regulations.
Artillery Drill Regulations.
Manual for Privates of Organized Militia.
Technique of Modern Tactics (Bond & McDonough).
Military Engineering (Beach).

HENRY B. SAUERMAN,
Captain Corps of Engineers, Illinois National Guard,
Member American Society of Civil Engineers,
Member Western Society of Engineers.

**Presented at the Western Society of Engineers'
Meeting, May 1, 1916.**

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FORTIFICATION

By CAPT. H. B. SAUERMAN, M. W. S. E.

MODERN TRENCH WARFARE.

The modern rifle, the machine gun, the howitzer and the new field gun are responsible for the modern trench warfare. These powerful weapons make it impossible for troops to give battle in the open field without suffering tremendous losses. Cover and concealment, either natural or artificial, are two of the main requirements of a modern battlefield.

Trench warfare has brought out no new developments. Advancing by sapping and parallels, mining and the use of hand grenades has not changed in principle; the application, however, has been more extensive with modifications to meet the new conditions and the more powerful weapons.

Trench warfare is generally divided into four stages:

1. The first stage is that in which the two armies come in touch with each other and after finding the open attack impossible, finally intrench. At this stage one army may take the defensive and the other army the offensive, or each army may attempt to attack the other.

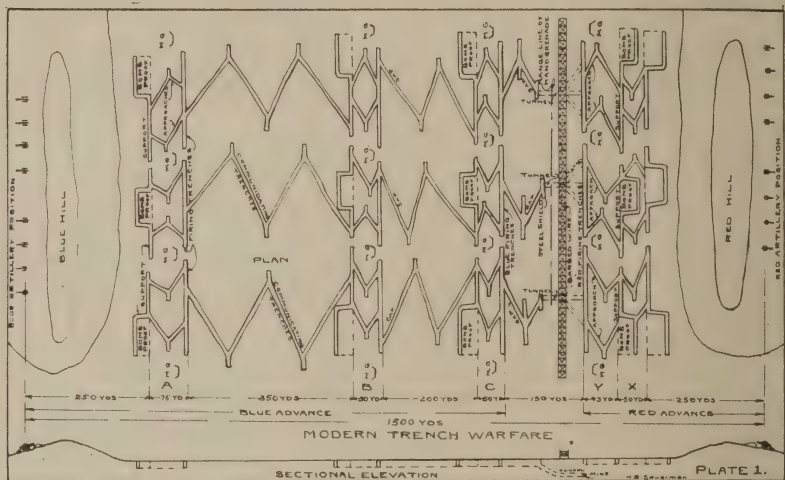
2. In the second stage they attempt to capture each other's trenches. To accomplish this, attacks are carried on over the open space between trenches and if these fail each army advances by moving forward at night and by intrenching in the new position.

3. In the third stage the armies advance upon each other mostly by digging trenches to the front. This method of advancing is called sapping and the trenches leading forward, usually in zig-zag fashion, are called saps. The heads of these saps are connected by trenches parallel to the original front or trench. Attacks in the open are also attempted at this stage.

4. In the fourth stage the trenches of these armies have come so near to each other that they can no longer advance by sapping. The advance by this method is stopped by the use of hand grenades and bombs which each army, without leaving the cover of its own

trenches, can throw into the trenches of the other army. At this stage the tunneling is carried out underneath the ground, the trenches are blown up and the craters caused by the explosion are occupied and are put in defensive condition by the army capturing them.

To illustrate this system of warfare, plate 1 has been prepared. In order to explain this system we assume that a Red force is invading the territory of a Blue force. The Blue force is encamped at the foot of Blue Hill and the Red invasion will proceed over Red Hill. When the Red advance guard reaches the crest of Red Hill it at once sends a message back to its commander advising him of the presence of the Blue force. The Red commander orders skirmishers to take position at foot of Red Hill and open an attack on the Blue Force. The Blue force answers with a vigorous infantry fire and as the Red commander sees the firing line of the Blue force receive heavy reinforcements, he at once decides to bring



any section that rises and attempts to move forward. After several unsuccessful attempts the men throw themselves on the ground and place their knapsacks or blanket rolls in front of them and continue firing. While some of the men are firing others unstrap their intrenching tools and start digging a shallow trench, throwing the earth in front of them for protection. Each man digs for a while and then fires at the enemy while his nearest neighbor digs. Meanwhile the artillery duel continues.

When night and darkness come both forces work with large intrenching tools. The Red force intrenches in position "X." They dig a firing trench and another trench 50 yards in rear of the firing trench. In this rear trench they also construct bomb proofs. The two trenches are connected by zig-zag approaches. The Blue force constructs similar trenches, but the distance between their trenches is 75 yards. In digging these trenches concealment is given the greatest consideration. The omission of the parapet entirely or very low parapets with the sod placed back on the face toward the enemy is common practice. Dummy trenches, made from the excavated earth, are used to deceive the enemy.

When daylight comes the artillery promptly opens fire on the trenches and the infantry forces take to cover in the bomb proofs. Only a small trench guard remains in the firing trenches. The men occupy themselves during the day, strengthening and improving their respective entrenchments. The machine guns are usually placed slightly in rear of the intervals between trenches and on the flanks. They are almost always masked and under cover so as not to attract the hostile artillery fire.

The second night the Blue force sends out skirmishers about 500 yards in advance of their position. The Red commander decides not to advance until heavy reinforcements arrive.

To avoid a surprise attack he sends out small reconnoitering parties, who discover the Blue skirmishers about 300 yards from their trenches. They open fire on the skirmishers at once and are reinforced by additional men from the firing trenches. This intermittent fire is kept up the entire night. The Red force finds it to their advantage to advance their line 75 yards and to convert the first firing trench into a support trench with bomb-proofs, as shown at "Y." The Red force also constructs wire entanglements in front of their position.

The Blue force constructs a second line of trenches at position "B," about 400 yards in advance of their first position.

At daybreak both forces start strengthening and improving their positions. Both positions are bombarded intermittently during the day. The Blue artillery brings a heavy fire on the wire entanglements of the Red force with the intention of destroying them. The Blue infantry force takes advantage of all possible means to advance their positions and, therefore, start sapping operations, which they find necessary, being in close range of the Red infantry fire. Several hours before dusk the Blue artillery opens

a heavy fire with high explosive shells. This fire is a steady fire directed on the Red trenches and wire entanglements. When darkness sets in this fire ceases.

Shortly after dark the trench guards of the Red force hear noises made by the Blue force cutting the wire entanglements. The Red force at once opens fire. The Blue force rushes forward with fixed bayonets. Many are shot down as they come up to the Red trenches. A portion of the Blue force finally succeeds in capturing a section of the Red trench, but their success is of short duration. The Red support is brought up and a machine gun on the flank of this captured trench brings a terrific fire into this trench. The men of the Blue force, who are not killed or wounded in this trench, escape in the darkness. Silence reigns for the rest of the night. In the morning it is found that the Blue force has constructed another set of parallel trenches at position "C." They have also connected these trenches to the saps which were started the preceding day by regular approaches.

The artillery cannot fire on the trenches now as the two forces are too close and the danger of hitting their own forces is very great. The Blue force now starts sapping operations and continues to a short distance from outside of the range of hand grenades and bombs. At the head of these saps small parallels are dug. The top of these parallels are covered over with logs and earth and a small steel shield with loop holes is placed in front of them. Sharpshooters placed in these parallels act as a guard and shoot at any Red man who dares bring his head above the trenches.

From these parallels the Blue force starts a tunnel, digging forward and gradually downward. This tunnel is about 4 ft. 6 in. high by 3 ft. 6 in. wide. When a depth of 15 ft. is reached the tunnel is continued on a level. When the tunnel has passed underneath the barbed wire entanglements, small branches are run to right and left of main tunnel. These branches are made 3 ft. 6 in. by 2 ft. 6 in. The smaller the tunnel the less noise and the quicker completed. When under the Red trenches a large earth auger (consisting of a heavy bar and large gimlet) is used to dig holes for the mines. Melinite is then placed in these holes and the Red trench is blown. This is usually done at night. Immediately when the trench is blown the Blue forces rush forward, the Red forces fire illuminating shells, when the Blue force rushes into the craters made by the explosion. The Blue engineers with picks and shovels and revetment, construct a parapet and also construct approaches back to their position. The ends of crater are blocked as only part of trenches are captured.

The Red force, after recovering from the shock, comes to each side of trench occupied by Blue force with the object to recapture same. They are met with a heavy rifle and machine gun fire and are forced to withdraw. The Blue force will then attempt to capture the balance of the Red trenches by sapping and mining as described above. The Red force will countermine and endeavor to drive out

the enemy and thus the struggle continues until one force or the other are practically exhausted and are driven or blown out of the trenches.

The hand grenades used in this warfare consist of hollow receptacles filled with high explosives. There are two types: the percussion type, which has a fuse arranged to explode the charge when it strikes an object. The other type has a time fuse which is lighted before grenade is thrown.

A small mortar is also employed, which is aimed almost straight in the air and will drop the small shell or bomb almost vertical into the enemy's trench.

For sapping the German army has now devised a digging or boring machine, with which they are able to accomplish the sapping operation in a very short space of time.

Plate 2 shows a detailed sketch of the tunneling and mining operation. This sketch is very clear and requires no further explanation.

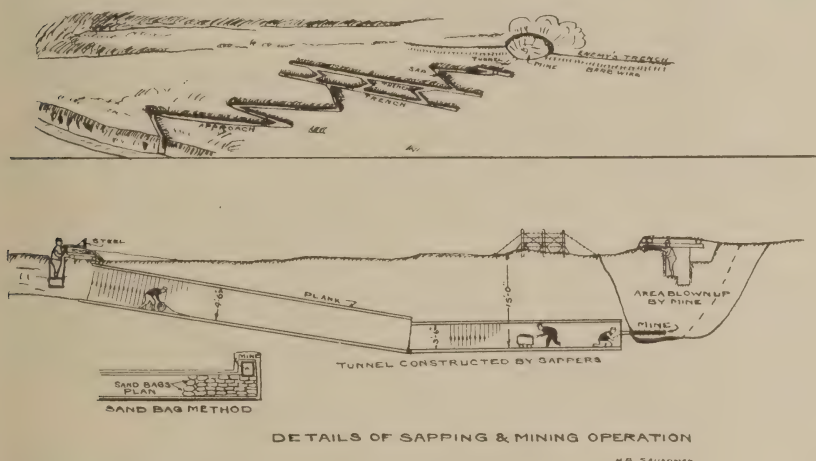


Fig. 2.

FORTIFICATION IN MODERN WAR.

The extensive use of trenches and field fortification during the Russian-Japanese War and the great European War proves conclusively that the proper and intelligent use of trenches and field fortifications, both for defensive and offensive operations, will have a most important bearing on the results of a modern battle.

It may be accepted as a principle, established by experience, that a line of men can not remain stationary under fire without cover, natural or artificial. This is true in every phase of action, whether advancing, retreating, or standing on the defensive. Cover at all times is desirable; on the move it may be dispensed with, at a halt never. In some cases the cover will be partly natural and

partly artificial, i. e., partial natural cover artificially improved. In a majority of cases, however, conditions of fire efficiency and concealment will require a line to be placed where it could not possibly live without artificial cover. Another principle, which may be accepted, is that on the offensive the line must determine the general position of the cover and not the cover the position of the line. The position of the line at any moment of a battle depends on tactical considerations and the progress and incidents of the fight. To prepare trenches in advance, except for defensive occupation, is to attempt to predict the future. It follows that all troops, not in a defensive attitude, must prepare their own cover after occupying a line or after they are halted. The importance is paramount of having available for instant use on every firing line the appliances and training to enable the men to get sufficient cover in the shortest possible time. This involves not alone the training of the men to dig with the tools provided, but also the knowledge and skill of their own officers to locate the trenches to the best advantage. There is no time to wait for instructions or advice from the outside.

Permanent fortifications have an inestimable value as a refuge for a defeated army to rally under, as a defense to communications, as a protection to the flank of an army, as a protection of a frontier, and as a threat on the flank or rear of an advancing foe.

Sea coast fortifications have a great value in protecting sea coast cities, harbors, naval bases and other strategic points along the sea coast.

FIELD FORTIFICATION.

Field fortification is an aid to tactics and it should be constantly borne in mind that fortifications are designed for tactics, not tactics for fortifications. A thorough study of the general tactical situation is the first and most important step toward a successful application of fortification. The following questions will arise in the study of the situation:

1. What is the general plan of operation?
2. What part are the fortifications to take in the general plan of operation?
3. Will the fortification be used for defensive operation only?
4. Will the fortification be used for offensive operation only?
5. Will the fortification be used for combined offensive and defensive operations?
6. What will be the strength of the attack infantry, cavalry and artillery?
7. What light arms, equipment, machine guns and artillery will probably be used by the enemy?
8. From what direction is the attack expected?
9. At what time is the attack expected?
10. What are the natural features of the ground at place where attack will take place?

11. What is the available armament and available strength of garrison for the fortification?

12. What are the available lines of retreat to a new position should the enemy's attack be successful?

It will not be possible to obtain all of the information as outlined above. Information relative to the strength and armament of the enemy, time and place of attack, etc., will in many cases be very vague and unreliable. All available means must be used to secure as much information and as reliable information as can possibly be secured. The time for securing information will usually be very short, and for this reason the judgment and reasoning power of the officer must be used to the fullest extent in determining many facts.

The work of Field Fortification may be divided as follows:

1. The general location of the fortification.
2. The division of the fortification into sectors and the garrison for each sector.
3. The division and disposition of the support and reserve.
4. The machine guns and their disposition.
5. The artillery position.
6. The disposition of the cavalry.
7. The trench trace and profile.
8. The overhead cover.
9. Loop holes.
10. Drainage.
11. Artificial concealment.
12. Clearing the ground.
13. Obstacles.
14. Dummy trenches.
15. Execution of work.
16. Observation, telephone and water supply.

THE GENERAL LOCATION OF FORTIFICATION.

The requirements of a well fortified position are:

1. Concealment.
2. Good field of fire.
3. Natural or artificial cover.
4. Obstacles for retarding or directing the course of enemy.
5. Easy and concealed communications for tactical movements of your troops.
6. Obstructed and unprotected communications for enemy.
7. Easy digging soil; free from rocks and roots.
8. Sufficient height to give good view over ground over which enemy will advance.
9. Natural flank protection.

Concealment is of the greatest importance. This does not only include the trench and parapet, but also the obstacles in front of same, for if these are not concealed they will assist the enemy in

locating the trenches in rear and the hostile artillery will further destroy same. Formerly the field of fire was given the greatest consideration. The war of today has demonstrated that a field of fire of 100 yards will be sufficient if it can not be extended without loss of concealment. Low parapets, the omission of parapets, a background, avoidance of sky-lines, narrow trenches, covered trenches, rounded crests and corners and the concealment of disturbed soil are all very effective in securing concealment.

For concealment against observation from aeroplanes and also horizontal concealment, the author suggests a canvas covered trench. The canvas can be painted any color to suit the surroundings, or by

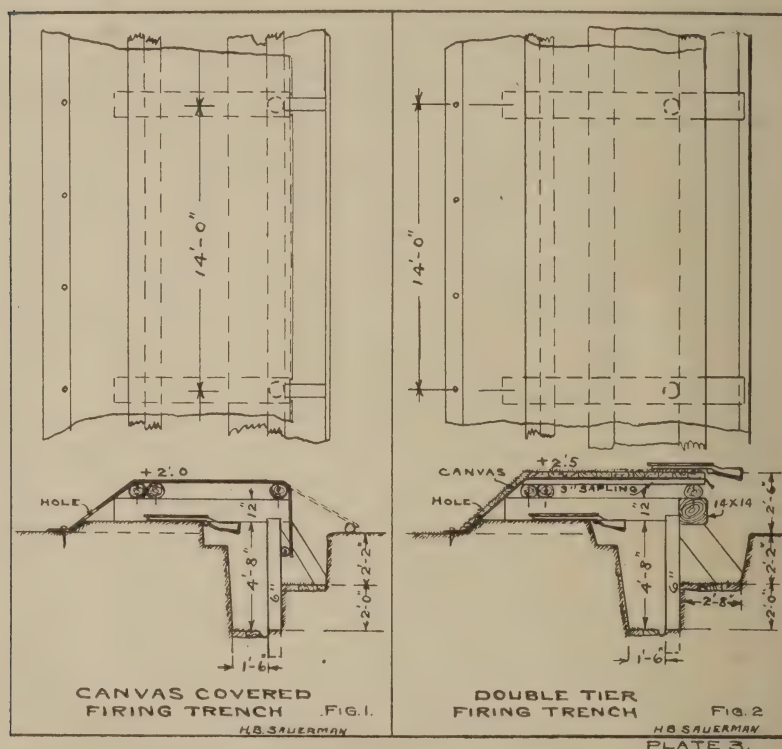


Fig. 3.

scattering lightly grass, earth or other matter over the canvas almost perfect concealment can be obtained within a short space of time. The canvas covering will further protect the garrison from rain and the direct rays of the sun. Figure 1 on Plate 3 shows an ordinary firing trench provided with the canvas cover, as suggested by the author. Figure 2 shows a double tier firing trench provided with this same covering.

The field of fire must permit of the full use of the defenders' weapons. This requires a level or slightly sloping open space in front of the trenches for 100 to 700 yards. A grazing or parallel to the ground fire is the most effective. Fire delivered at a considerable angle with the line of trench is not very accurate. The limiting angle for good results is about 12 degrees. Trenches should, therefore, be fairly straight and at right angles to the fire.

Cover, either natural or artificial, is essential for the protection against infantry or artillery fire. Natural cover is usually obtained behind crests of hills, in ravines, dry river beds, etc. Artificial cover is usually obtained in sunken roads, behind road and railroad embankments and in dry ditches or special trenches.

Obstacles for obstructing or directing the course of the enemy consist of marshes, rivers, valleys, cliffs, hedges and forests with heavy undergrowth. All these natural obstacles may force the enemy to attack only from one line and direction. The defender will then have the advantage to concentrate his entire force and means at the point of attack and prepare the position in advance. Where the enemy can be forced to attack over a narrow well swept front, the attack (everything else being equal) is almost certain to fail.

Easy and concealed communications can be obtained behind rising ground, through woods, through ravines, through large standing corn, etc. High sites furnish better protection for communicating trenches than do low sites, but this advantage of the high site is oftentimes offset when the defenders are compelled to deliver an ineffectual plunging fire. Where natural concealment for communications can not be obtained artificial zig-zag or traversed communicating trenches must be built. Cover trenches for supports and reserves must be constructed in locations where the country is flat.

Where it is possible, the enemy should be forced to attack over difficult ground, requiring crossing of streams, etc., and where he will be exposed as much as possible, where his fire can not be developed and where his movements will be impeded.

Easy digging soil, free from large stones and roots, is very desirable where the time is very limited for the construction of trenches.

Authorities differ regarding the height of a position. It is desirable to have a certain amount of command for a defensive position. This height need only be sufficient to give an unobstructed view over the ground in front. In flat open country this height may be very little. The slopes to the front should be gentle and evenly sloping. A strong defensive position is one where one or both flanks are protected against attack by natural or artificial obstacles—rivers, deep marshes, mountains, etc., form good natural obstacles for protection.

It is very apparent that very rarely a position will be found which will meet all of the conditions and requirements as outlined,

but it is also very evident that the position which meets most of the conditions and requirements will be the most easy to defend. The officer, should, therefore, carefully study his position accordingly, for upon the selection of the position may depend the results of the battle.

THE DIVISION OF THE FORTIFICATION INTO SECTORS AND THE GARRISON FOR EACH SECTOR.

Field fortification, for tactical and administrative reasons, should be divided into independent sections of such size as can be well commanded by one man.

Such a division is an aid to tactics in that it allows the tactical units with their supports, reserves, supply, etc., to be kept together, and the duty and responsibility of attending to the many details can easily be divided by the commander among the subordinate officers. It is very apparent that a better field control will result with such an arrangement, and it is also very evident that such a division will

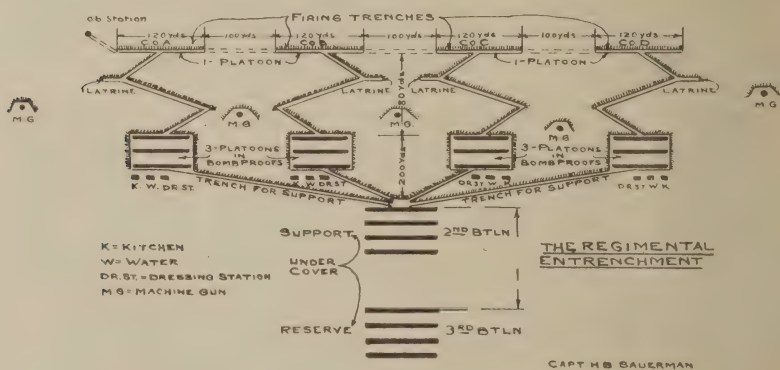


Fig. 4.

aid the administration and supply department in the same manner. To illustrate the arrangement of a modern field fortification sector, Plate 4 has been prepared. Briefly, the arrangement, as outlined, is as follows: Firing trenches are designed for full company units. A small trench guard is always stationed in the firing trenches. This may consist of one platoon or less in case of artillery bombardment. In case of threatened infantry attack the other platoons of each company which are stationed in the bomb-proofs are rushed forward through the communicating trenches and take their place in the firing trench.

When the entire first battalion is in the firing trench, the second battalion moves up into the support trench and in the bomb-proofs. These bomb-proofs are loop-holed to permit of firing to the front and flanks. In case of capture of the first firing trench, the first battalion will fall back to the support trench and there combine

with the second battalion to stop the enemy's advance ; under normal conditions the second and third battallions remain under natural or artificial cover and occupy the trenches only when conditions require it. When conditions require it the arrangement can be modified so that two battalions can be placed in the firing trenches with only one battalion in reserve. The machine guns are placed approximately as shown. In this location—they are in position to deliver a fire between the intervals of the firing trenches and they can also be rushed forward to deliver a flanking fire attack on the firing trench in case it is captured and occupied by the enemy. The machine guns can also be placed so as to protect the flanks of the outer firing trenches. All machine guns should be masked or concealed so as not to attract the hostile artillery fire.

THE DIVISION AND DISPOSITION OF THE SUPPORT AND THE RESERVE.

Major W. W. Harts, in his excellent work, "Notes on Field Fortification," in the Professional Memoirs, gives the following information regarding the garrison, support and reserve:

"From one-quarter to one-half of the entire force should constitute the general reserve and the remainder be distributed in the various sections of the front as needed. In each section it is advocated that about one-quarter to one-half of the force assigned to it should constitute the section reserve, and of the troops remaining about one-half or two-thirds should be supports. About one-fourth to one-sixth only of the section's force will actually be in the trenches before being attacked. It seems to be desirable to reduce the force of men actually in the trenches to the smallest number consistent with safety. No exact proportion of reserves and supports can be given for all cases and the foregoing is only stated as a guide in forming one's own decision, which must always depend on the conditions peculiar to the ground, including the shape of the front, whether straight or curved, the size of the garrison, the enterprise of the enemy and the interior communications.

"But room in the trenches must usually be made for all the troops in the section, including perhaps space for some of the general reserve, so there must be some calculation made as to how much trench must be built or how much front can be occupied.

"Trenches must always be able to furnish enough aimed rifle fire to stop any ordinary infantry attack across the open space in front. It is plain that this will vary greatly in different terrain. One might suppose that the enormously increased power and rate of fire of the modern rifles had lessened the number of rifles necessary, and that the old rule of thumb of one man per pace of firing line is no longer required. Such density is no longer necessary, except perhaps for a short time for repelling assaults after the attacking troops have managed to bring a large force within close assaulting distance. At such times the maximum amount of fire possible is needed. Men can not use their rifles accurately if occupying less space than one pace of the front. This may then be adopted as a maximum density required for any part of the front where a

close attack may be delivered. This assumes that a part of the general reserve is on the line. At other places less hard pressed more length of trench and less density will be possible. An English authority has even stated that one man to every eight or ten paces is enough to check any infantry assault on a well chosen position, or including reserves and supports from two to five paces per man. We may safely conclude that from 1 to 4 yards per man, including sectional reserves and supports, are limiting estimates depending largely on the ground. The density suggested in our field service regulations, including supports and local reserves, is one man per yard, giving a front of 750 yards for the battalion, including intervals of 100 yards between companies, 1,500 for the regiment, and 4,500 for the brigade. The judgment of the officer as to the strength required will have to be exercised in each of the larger parts of the line in order to have it fairly balanced, increasing the density in some places and decreasing it in others."

THE MACHINE GUNS AND THEIR DISPOSITION.

Machine guns are now recognized as one of the most potent factors in battlefield operations. Our Field Service Regulations, 1914, Par. 34, gives us the following information:

"Machine guns are emergency weapons. They are best used when their fire is in the nature of a surprise to the enemy at the crises of combat. Their effective use will be for short periods of time—at most but a few minutes—until silenced by the enemy. When engaged they must be used to the limit of their effective capacity. On the offensive they find their use in assisting the attack to obtain fire superiority temporarily lost and against lines of trenches which are to be assaulted. In the defensive they are used against large targets visible for a short time only, and on advancing lines of the enemy's infantry within the short and mid ranges. The effect of the enemy's fire, particularly his artillery fire, on machine guns, is lessened by their employment in small groups."

In event of an assault they enable a heavy fire to be developed at a point where the enemy is strongest, provided the machine guns are placed so as to admit of their free use. For the defense of flanks of both infantry and artillery, for the defense of ditches, for positions where infantry would be visible or liable to enfilade fire, the machine gun posted behind natural cover or other concealment will give excellent service. Machine guns are placed between intervals of trenches as shown in Plate 4 and also on the flanks of infantry and artillery positions. They should be well concealed and the emplacement so constructed as to afford a maximum protection to the gun detachment consistent with the free use of the weapon. Splinter-proof overhead cover is desirable and should be provided wherever possible. Shelter should be provided for both gun and detachment when not engaged. It will sometimes be found to advantage to connect emplacements by communicating trenches.

Fig. 1, Plate 5, shows a Single Machine Gun Emplacement. Fig. 2 shows a Double Machine Gun Emplacement.

Lieutenant Henry J. Reilly gives the following report regarding the value of machine guns in the present European war:

It is particularly in the defense of an intrenched position that machine guns are useful. Here, as in a fight in the open field, they must not open fire too soon, or the hostile artillery will wipe them out. Therefore, they generally remain silent until the enemy's infantry comes out of its trenches and starts across the intervening space in its endeavor to capture its opponents' trenches. Then the machine guns open fire and keep it up until the last of the enemy left alive or unwounded have run back into their own trench or until captured or put out of action by a hand grenade if the attack is a success.

The Germans frequently arrange their trenches so that if occupied by the enemy a machine gun can fire down them, thus enfilading him and driving him out. If the configuration of the

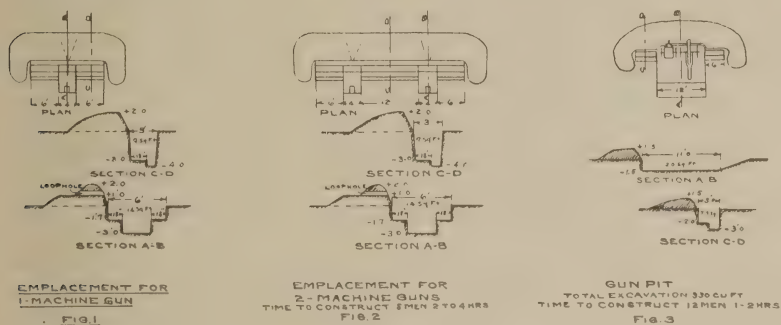


Fig. 5.

ground will permit it, they place most of their machine guns, not in the first line of trench, but in some position back of it. This is done to avoid probable destruction by the heavy shelling to which a trench is subjected by the enemy's artillery before an attack is made.

In accordance with this principle, where the Germans have been able to prepare a position ahead of time, they pick out a gentle slope and put three lines of trenches on it. The machine guns are placed in the last line, thus being able to shoot not only over the first two lines at any approaching enemy, but making a strong third line very difficult to capture, even though the first two lines are captured. Also until this third line is captured and a hole thus broken entirely through the position, little is gained by the capture of the first two lines.

Frequently in Poland there have been large stretches of country where the invaders have had no other desire than to remain on the defensive. In these stretches the Germans strongly intrenched and

garrisoned the important points. Between these points they constructed several lines of trenches, each with a very wide barb wire entanglement in front.

These trenches would have comparatively few troops in them, but a considerable number of machine guns. While a Russian attack might succeed in breaking through most of the entanglements in spite of the machine gun fire, it would take them so long that the German reserves from central points in the rear of the line would have ample time to get up.

THE ARTILLERY POSITION.

The artillery position is usually selected by the chief artillery officer after he learns the general situation and requirements from the commander.

Artillery positions are generally in rear of the intrenched infantry positions and are concealed from view usually by natural cover. When conditions permit, the artillery should be placed in a somewhat commanding position. Due to the perfection in firing by indirect laying, guns are now usually placed in rear of the crest of the hills. The advantage of such a position is easy concealment and easy concealed withdrawal, both of which are more important than direct fire. Concealment and mobility are in fact the most important factors. Dispersion is very necessary to reduce the hits of the hostile artillery, and with the improved field telephone system, guns can be scattered over a wide area without the loss of control. There should be numerous alternate emplacements, with casemates for the protection of the men. This will allow changes of position with a minimum loss of time. Positions should be selected to furnish a concentrated cross fire on all possible lines of advance of the enemy. Whether the heavy guns should be placed to the front or to the rear depends very much upon the enemy's armament; if he has only the small caliber guns, the large guns may be kept in the rear; if the enemy has large caliber guns it will be necessary to place the heavy guns to the front to prevent him from building his batteries.

Good sites for observation stations are a prime necessity. They should be well concealed and connected by telephone to the different battery commander stations. Where it is possible, emplacements should be connected by concealed approaches.

The light field guns, which in practically all armies are about three-inch, are generally found in the zone from 2,000 to 4,000 yards from the enemy's trenches. The heaviest guns, such as the 305 millimeter (about twelve-inch) howitzer, are found at from 6,000 to 8,000, or even more, yards from the enemy's trenches.

The guns of the intermediate caliber, such as ten-inch howitzers and fifteen centimeter-rifles, are found somewhere between the light field guns and the heaviest ones.

The Austro-Hungarian 305-millimeter howitzer has been extremely efficient throughout the war. A large part of the work

credited by the allies to the 420 millimeter has in reality been done by the 305. One of the marked features of this gun is its mobility.

The gun, the carriage in two parts, and a steel platform on which the gun and carriage rest during firing, travel on four steel trucks with heavy wheels, which are pulled by one or more traction engines, depending upon the state of the roads.

When the firing position is reached, the ground is leveled, the steel platform put down, and the gun and carriage mounted on it.

The 3-inch field gun, the 6-inch long range heavy guns and the 5-inch howitzer and mortar are usually employed in the field fortification.

The mortars and howitzers are usually located in retired position on the reverse side of hills, in ravines, etc.

In addition to the heavier guns, the 1-pound automatic and the 3-pounder and 6-pounder rapid fire guns are employed to good

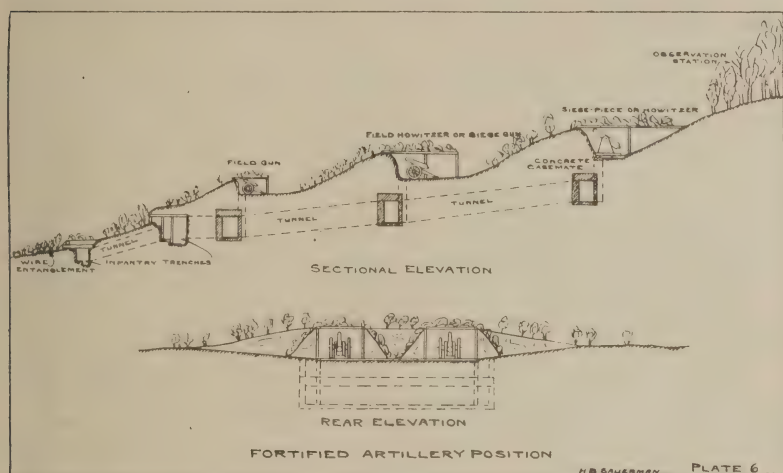


Fig. 6.

advantage. In case of assault they will bring a heavy fire to bear on the enemy.

Fig. 3, Plate 5, shows a very simple and easily constructed gun pit. The pit can easily be modified to meet different conditions and the low parapet admits of easy concealment. It was used extensively by the Russians in the Japanese War.

Plate No. 6 shows a fortified artillery position on the front slope of a hill. Such a position is a difficult one to conceal and further makes it very difficult to change position without being observed by the enemy. Brush, canvas, trees, sunken roads and dry ditches will oftentimes help to overcome these disadvantages. It will be noted that the guns shown in this plate are all firing over the infantry trenches. This is a very common practice in the present

European War. The guns should be placed at least 600 yards in rear of the infantry position so as to protect the artillery position from flank and rear attacks and further not expose the infantry to loss from premature bursts. For the sake of showing the gun positions clearly, they are all shown in cross section. In actual practice these guns would not be placed one directly in rear of the other, but would be widely scattered.

THE DISPOSITION OF THE CAVALRY.

Cavalry can render valuable service in connection with field fortification by the performance of the following duties:

1. Reconnoitering the enemy's position and securing information as to his strength, armament, disposition of troops, etc.

2. Delaying the enemy's advance so as to give the troops sufficient time to dig their trenches.

3. Selecting and holding strong defensive positions in advance of the infantry.

4. Protecting the flanks of a fortified position.

5. Threatening the flanks of the enemy and forcing him to attack along certain lines.

6. Clearing the ground by tramping down crops, such as standing corn, etc.

7. Performing demolition work.

Cavalry in modern war will seldom be called upon to make mounted charges. It has the great advantage of mobility. Infantry carried by motor trucks does not have the mobility that cavalry has, because the trucks are confined to good roads and also on account of the small number of trucks available.

The cavalry in the present European War is mostly employed in seizing strong position in advance of the infantry and holding these position by fighting dismounted until the infantry arrives. When the Allies were trying to extend their lines to Antwerp and the Germans were trying to reach the Belgian coast in October, 1914, the cavalry of both armies played a most important part in the region of Lille and Ypres.

Cavalry played a most important part in the Allies' retreat and the German's advance to the Marne.

Cavalry is also employed in filling gaps between infantry units. Owing to its great mobility, it can reach decisive points long before it would be possible for infantry to do so. The present war shows many instances in which cavalry filled important gaps.

THE TRENCH TRACE AND PROFILE.

Prepared fortified lines of resistance will consist normally of successive lines of trenches or supporting points with intervals, the intervals being such that mutual defense by cross fires and flanking fires is assured. The supporting points will usually be groups of rifle trenches combined with natural topographical features. The

intervals between trenches and supporting points will vary from 100 to 800 yards.

The flanks of a trench or a position will always be tempting points for the enemy's attacks and they should therefore be secured by resting them on impassable obstacles or, if this cannot be done, by echeloning them to the rear and placing reserve trenches close at hand.

Long trenches are not desirable even where the ground permits of their application, which it ordinarily does not. Any long trench once located by the enemy easily leads to the disclosure of the remainder. A long trench penetrated at any point will generally become untenable. For these reasons it is considered preferable to limit the length of a single trench to that required for a company and if a greater development of fire is needed, additional trenches of company, platoon or even squad length may be constructed. The several trenches of a group need not and generally would not be on the one line, but might be separated in depth as well as laterally.

The trace of a trench should follow a contour. Men standing about 11 paces apart may hold a tracing tape at the height of parapet. By looking all along the tape, it will be seen whether each part of the parapet will command the ground in front of it. If the command is greater than required, the parapet may be lowered or retired. Note also whether the longest trenches are on the sides of the easiest approach, if not trace must be modified. Fairly straight lines at right angles to the delivery of fire are to be preferred. If curves must be introduced they should have a radius of at least 20 yards. All trenches should be long enough to give an effective volume of fire. A squad trench 11 paces or 9 yards is about the minimum.

Tracing and profiling are not independent operations. The trace depends upon the profile and the profile upon the trace. The profile, however, is fairly well standardized while the trace must be determined by the circumstances and conditions. In field fortification the term trace usually designates the horizontal projection of the interior crest. This trace, as stated before, should follow a contour; if the contour curves, the trace should also curve; sharp angles should be rounded off so as to make them less conspicuous. Plate No. 7 shows a trace of a Battalion Supporting Point in accordance with the German Regulations 1910.

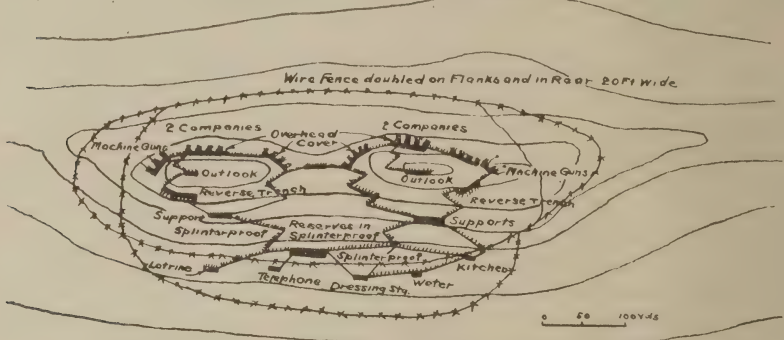
Due to the improvements in rifle and artillery fire, the high parapets and broad trenches of the past years have been replaced with narrow trenches with very low parapets or with parapets entirely omitted. If a parapet is used, the crest should not be over 18 inches above the ground and the surface should be a straight gentle slope, not steeper than 1 on 6. Both these conditions help considerably toward concealment. The front wall should be as near vertical as possible; this provides better shelter and helps the soldier when in firing position. An elbow rest of 9 to 12 inches is also an aid. Most authorities state that a height of 4 ft. 3 in. to 4 ft. 6 in. from the bottom of the trench to the crest of parapet is

necessary for a man firing while standing. The author's experience has been that 4 ft. 8 in. will better meet the average condition on account of the dirt along parapet being disturbed by movement of rifles, etc. Furthermore, in case of heavy rains the height of parapet will be reduced. Should this height be too great for certain soldiers it can readily be decreased by throwing a little of the dirt to one side.

There is a practical limit to the narrowness of a trench. A trench narrower than 2 ft. can not be dug and used to good advantage. It is too narrow for two men to pass in it or for a man to sit with his back to the front wall; 3 ft. is the limit for this purpose.

Major Harts gives the following essentials of the profile:

First, a low bullet-proof parapet not over 18 inches high with a single gentle slope not steeper than 1 on 6 and an elbow rest 9 inches below the crest; second, a narrow trench with vertical or nearly vertical sides and of sufficient height to cover a man standing,



Type of
IDEAL BATTALION SUPPORTING POINT.
GERMAN REGULATIONS 1910
2 PLATOONS IN TRENCHES
2 " " SUPPORT
2 COMPANIES IN RESERVE

TRENCH ROOM FOR ENTIRE BATTALION 1 YD PER MAN
ABOUT 400 YDS LONG OVERHEAD COVER FOR 2 PLATOONS.

Fig. 7.

and wide enough to sit in and permit another to pass; third, some protection from enfilade or oblique fire by using traverses or special arrangement of the ground plan, and fourth, a bottom slope with a gutter for drainage. The following tables and information relative to range and penetration will assist in determining the necessary thickness of parapet:

RANGE.

Range	Rifle	Field Artillery	Heavy Artillery
	Yards	Yards	Yards
Distant	Over 2,000	Over 4,500	Over 6,500
Long	2,000 to 1,200	4,500 to 3,500	6,000 to 5,000
Effective	1,200 to 600	3,500 to 2,500	4,000 to 2,500
Close	Under 600	Under 2,500	Under 2,500

PENETRATION OF RIFLE BULLET.

	Inches	
	200 Yards	600 Yards
Commercial Steel.....	0.30	0.20
One-inch broken stone, gravel.....	4.80	4.28
Hard coal between 1-inch boards....	9.00	7.00
Brick masonry, cement*.....	2.20	1.16
Brick masonry, lime*.....	2.40	1.14
Sand, dry†.....	18.18	11.96
Concrete, port. 1-3-5.....	3.00	1.86
Oak	26.46	12.46
Sand, wet.....	30.00	13.00
Pine	25.72	13.00
Earth, loam.....	30.00	16.12
Grease clay.....	60.00	32.00

EFFECT OF ARTILLERY FIRE.

Up to 3,000 yards, the 3-inch field gun, using high explosive shell, is effective against ordinary types of overhead cover for field trenches, brick buildings and stone walls 2 feet thick. It is ineffective against earthen parapets.

The heavier types of field guns and howitzers are effective against all kinds of field works, and protection against this kind of fire must be secured by concealment.

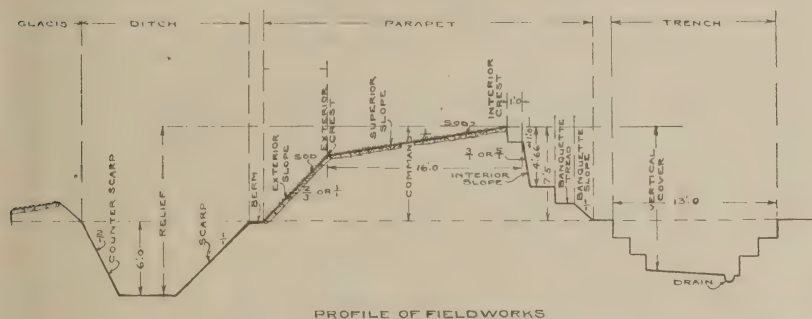


Fig. 8.

The thickness of ordinary earth required to resist penetration at usual battle ranges is 3 ft. for rifle fire, 10 to 24 ft. for field guns.

Plate No. 8 shows a profile of field works on which the names of the component parts are indicated. Plate No. 9 shows our standard profiles as outlined in our Regulations. Plate No. 10 shows a progressive trench profile adopted from German and English regulations.

*For single shot.

†In sacks, about one-half these figures.

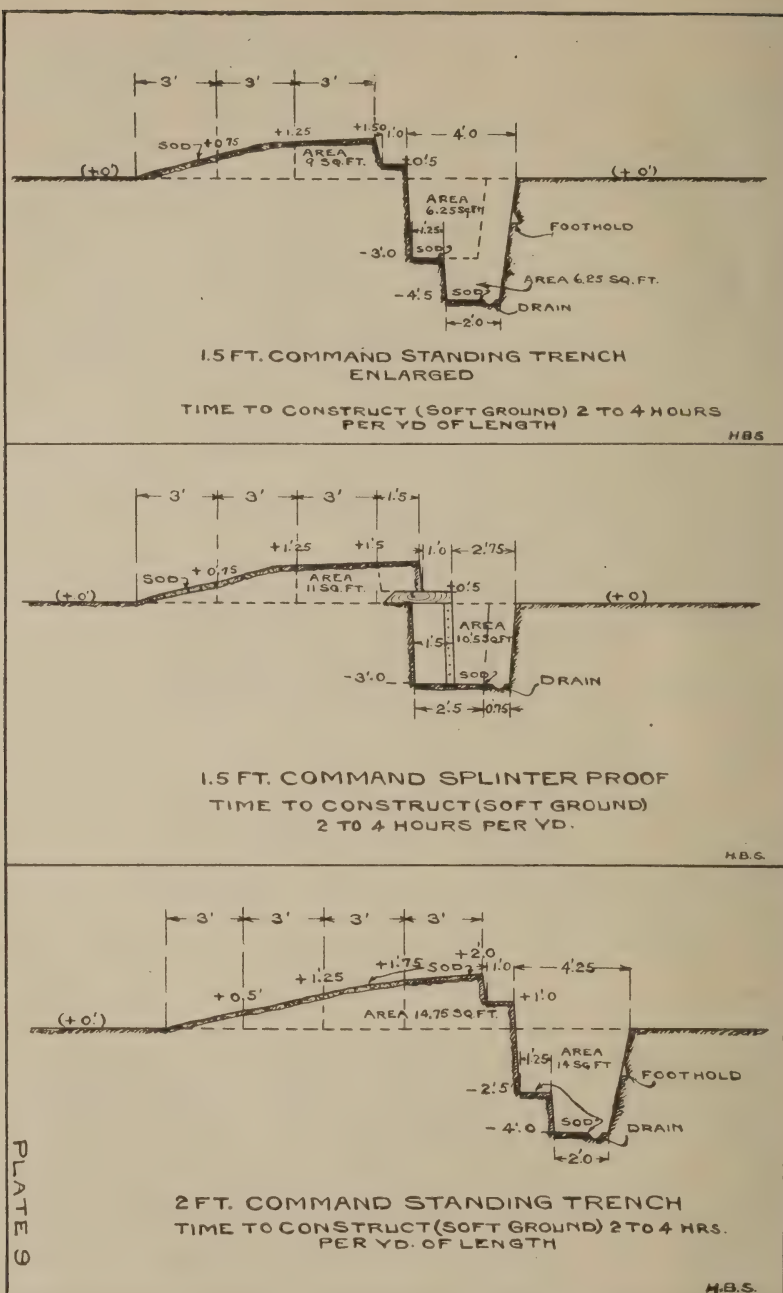


Fig. 9.

OVERHEAD COVER.

Overhead cover should be provided wherever and whenever possible. This need not necessarily be of massive nature, but in many instances it need only be sufficient to give good concealment.

Our Engineer Field Manual gives us the following information regarding thickness of overhead cover:

For splinterproofs 6 to 8 inches of earth is necessary with a timber structure sufficient to carry the load. For bombproofs a minimum thickness of 6 inches of timber and 3 feet of earth is necessary against field and siege guns and 12 inches of timber and 6 ft. of earth is necessary against howitzers and mortars of a heavy siege train. A German military engineer recommends a thickness of earth equal to twice the depth of penetration of the shell before bursting and a supporting structure of sufficient strength to safely carry from 2 to 4 times the weight of earth coming on same.

Col. von Schwartz states that during the siege of Port Arthur

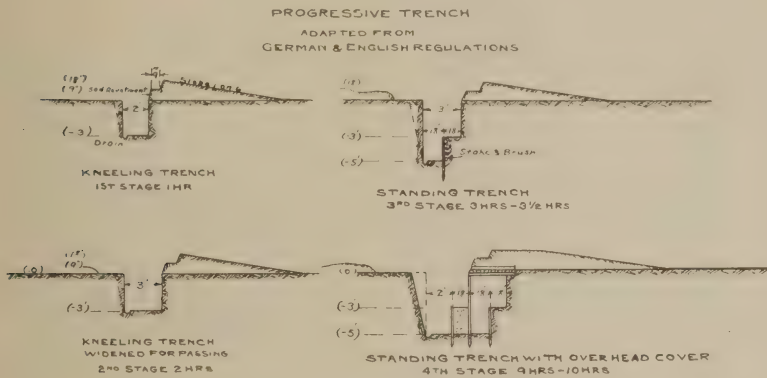


Fig. 10.

a 5-ft. thickness of clay tamped in one-foot layers and placed over a concrete roof successfully withstood the repeated action of a 6-inch shell. For concrete covering Colonel von Schwartz recommends a thickness of 9 ft. to resist the 11-inch shells, such as were used at Port Arthur.

Our sea coast fortifications are provided with a 10-ft. Portland cement concrete overhead cover.

An earth covering from 5 to 10 ft. in thickness placed over concrete roofs greatly assists in taking up the impact of the shell.

The German practice in the present war is to provide dug-outs from 25 to 35 ft. below the surface and in front of their trenches. These dug-outs are reached by half-galleries. Plate 11 shows two types of these dug-outs with galleries for same. The British provide recesses in their front trench walls, as shown in Plate 15.

LOOP HOLES.

The use of loop holes must be determined by the local conditions. The chief disadvantages of the loop holes are the reduction of rifles and the restriction of the fire to a frontal direction. Visible loop holes are very dangerous and to aid concealment the rear of the loop hole should be shut off from any light.

As concealment is one of the most important factors in trench warfare, the use of loop holes is very common in the present European War. The most serviceable form of loop hole consists of a pyramidal box made of 2-inch plank with a steel plate spiked on small end of same and pierced for fire. The steel is $\frac{1}{2}$ inch thick and the opening in same is about 2 inches by 4 inches. This opening is usually provided with a movable lid which closes the opening when not in use. This is known as the "hopper loop hole."

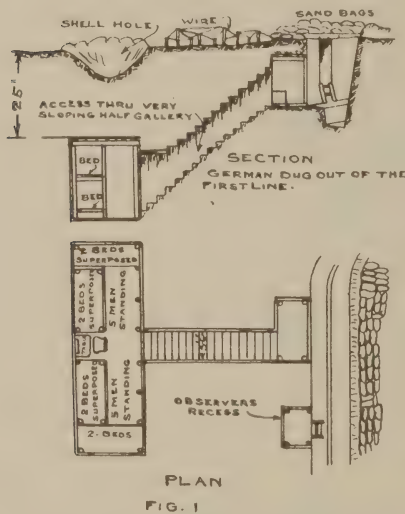
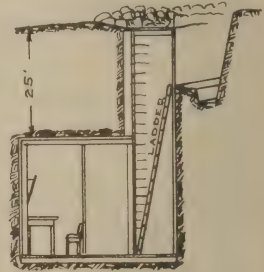


FIG. 1



SECOND TYPE OF GERMAN DUG-OUT

FIG. 2

Fig. 11.

Loop holes can also be readily constructed with sod or sand bags.

Loop holes must not be closer than 1-yard intervals. If placed closer they will weaken the parapet. *All loop holes must be masked* so as to avoid discovery by the enemy. A continuous loop hole may be readily constructed by placing two 14-inch diameter logs along and above the parapet with supports 14 feet apart. The logs raised from 3 to 6 inches above parapet so as to give the men sufficient space to fire through. Concealment can be secured by throwing grass or dirt over logs so as to blend with the surroundings.

DRAINAGE.

The drainage of trenches is of great importance. When trenches are constructed under threatening weather conditions, or where trenches are constructed near the foot of a hill or in low level country, drainage becomes a prime necessity even if the trenches are to be occupied for only a comparatively short time.

Trenches should at all times be made as dry as possible. The floor of the trench should be made to slope backward to a small drainage ditch or gutter which carries the water to a sump or to a point where it can be disposed of otherwise. Hand-operated pumps or small power-driven pumps can oftentimes be used to good advantage. Provisions should always be made for excluding surface drainage when constructing trenches on the side of a hill. Fascines laid on floor of trench will aid very much in keeping the feet dry. Nothing will take the fighting spirit out of a soldier quicker than will wet feet or wet lower garments.

ARTIFICIAL CONCEALMENT.

With the extensive use of the high power weapons and the howitzers of small and large caliber, the question of sufficient thickness for both horizontal and overhead cover becomes a serious and difficult one. The author fully agrees with the school of military engineers who believe that the best protection lies in concealment and mobility. Even if the protection by thickness of cover alone would be advisable at times, the element of available time will enter into the problem and in many cases will not permit the construction of sufficient thickness of cover.

Low parapets, sodded parapets, the entire omission of parapets, avoidance of skyline, certain backgrounds, narrow trenches, curved traces and concealment of disturbed ground will aid greatly in securing concealment. Obstacles must also be concealed to avoid their destruction by the enemy's artillery and further avoid aiding the enemy in locating the position by means of the obstacles. Lighting systems should be of a flashing rather than of a constant nature.

The author again wishes to bring the reader's attention to his canvas system of concealment, as shown on Plate 3, for infantry trenches, and on Plate 17, for permanent fortification. Canvas will not only offer good concealment by giving it the color of the surroundings, but it will also furnish protection from the rays of the sun and from rain, sleet and snow.

Even the armored turrets could be concealed to good advantage by means of this material. The canvas could be made up in rolls so that it could readily be handled by two men.

CLEARING THE GROUND.

Clearing the ground to obtain a good field of fire should be given very careful consideration. A clear field of fire of 100 yards in front of the trenches will be sufficient if it cannot be extended

without loss of concealment. Large trees in standing position give less concealment than when lying on the ground. Thickets and brush can be cut down or burned. Large high-standing crops, such as corn, cane, etc., can readily be tramped down by cavalry or leveled with horses hitched to some kind of a drag. Special attention should be given to objects which will afford probable concealment for the enemy's artillery or machine guns. These objects should be destroyed. If the sacrifice of labor and time is not too great and good concealment is not sacrificed, a field of fire of 800 yards will oftentimes be found of great advantage.

OBSTACLES.

Obstacles assist in strengthening defensive positions.

Obstacles should form no shelter for the enemy.

Obstacles should be sheltered from the enemy's artillery fire wherever possible. Obstacles should be difficult to remove. Obstacles should not interfere with counter attacks.

Obstacles should be placed from 25 to 100 yards from the trench.

Obstacles should be concealed. This can be accomplished by scattering small pieces of brush over same but this brush must not be of such density so as to afford a screen for the enemy. Another effective method is to provide a shallow wide trench for wire entanglements, etc.

Col. Fiebeger, in his work on Fortification, gives us the following information relative to obstacles:

"Obstacles are employed in connection with fortifications to protect the works from surprise, to break up the assailant's formations, and to hold his troops for a time under the accurate fire of the defender. They should be concealed from the assailant, they should neither give him cover nor conceal his movements, and they should be difficult to destroy. Obstacles may be placed either in front of or along the line of defense. If in front of the line, they are most effective if they are under the close infantry fire of the trenches, under close observation at night, near enough to the line of defense to compel the assailant to cease his artillery fire before his infantry reaches them, and far enough from that line to save them from destruction during the artillery bombardment which precedes the infantry attack. Obstacles along the line are either in the ditches of the fortifications or in the intervals between the works of the intrenched line. For passive defense the obstacles in front of a defensive line should be continuous; for active defense they are employed only in the defense of salients or key points."

Plate 12 shows different types of obstacles, including some of the latest types used by the German army.

DUMMY TRENCHES.

Dummy trenches are useful in diverting the enemy's fire. These trenches are usually constructed with the waste ground from the

regular trenches or they are quickly constructed by means of horses and plow. The appearance of these dummy trenches must be of such appearance so as to deceive the enemy, otherwise it is very apparent that they will fail in their purpose.

EXECUTION OF THE WORK.

Fortification, like all other work, should be executed in the shortest possible time and with the least fatigue of the men.

The officer must bear in mind that 2 hours of digging will leave a soldier fit for both fighting and marching, while 4 hours of continuous digging will unfit him generally for either fighting or marching.

In executing the work *the first step* is to mark on the ground the projection of the interior crest, sometimes called the firing crest. It may be marked continuously by stretching a line or by

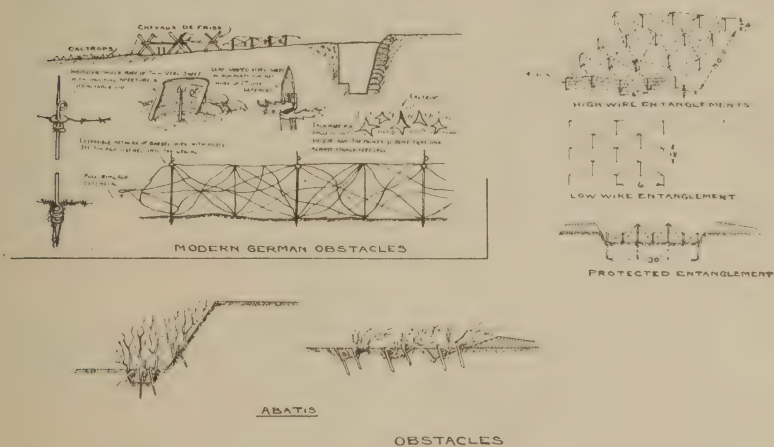


Fig. 12.

scratching the surface with a pick. The author suggests that a line be stretched at a height of the interior crest supported on stakes set 11 paces or approximately 9 yards apart. These stakes will mark the length of a squad trench with an allowance of $1\frac{1}{2}$ feet on each side for a traverse. *The second step* is to determine the depth and width of trench and to check the height of parapet so as to assure a clear field of fire. *The third step* is to mark the toe of parapet and also lay out the ditch if one is required. This is best accomplished with stakes set about 2 yards apart.

Working parties should be made up so far as possible of entire organizations. A battalion should be ordered to send one, two or three companies; a regiment, one or two battalions, and a brigade, one or two regiments.

Work should be performed by complete units—this will greatly

assist in control and placing responsibility. The author believes the best results can be obtained by assigning one squad to each 9 yards of trench (this is the squad length, 1 yard per man and $1\frac{1}{2}$ feet at each end for traverse) with a corporal in charge of each squad. The corporal is held responsible for the men and work performed. To place a detachment on the work, the organization comprising it approaches the tools in column of files, rifles slung, pass between the piles of tools, shovels on the right, picks on the left. Engineer soldiers at each pile hand tools to the men as they pass. The corporal or squad leader places himself alongside the rear file of his squad, he takes a shovel while the file on his side takes a pick. Each squad leader then conducts his squad in column of files to the rear of the portion of the trench to be constructed by his squad. He usually halts his squad about 3 yards in rear of the cutting line and parallel to it. Work is started at the command: Commence work! The work should be divided into 2-hour tasks for each man. Weather conditions must at all times be taken in consideration. There should be one-sixth more men than theoretically required. Assuming men at 5-foot intervals and neglecting fractions the number of hours required to dig a trench, is the section of trench in square feet divided by 5 for easy; 4 for medium, and $2\frac{1}{2}$ for hard soil.

The table below gives the amount of work that can be accomplished in one hour by one man:

EXCAVATION—

In easy soil—

First hour.....	cubic feet, 30
Second hour.....	cubic feet, 25
Third hour.....	cubic feet, 15
Thereafter continuous work.....	cubic feet, 10

in hard soil, about half the above.

In loose earth, 60 cubic feet.

Filling sand bags, 20 bags (0.5 cubic foot each).

REVTMENT CONSTRUCTION (Material and tools on hand)—

Rough brush wood or plank.....sq. ft. per man, hour, 40

Brushwood hurdles, rough—

Making	sq. ft. per man, hour, 15
Placing	sq. ft. per man, hour, 30

Sand bags—

Filling	sq. ft. per man, hour, 10
Placing	sq. ft. per man, hour, 20

Sod—

Obtaining sod for.....	sq. ft. per man, hour, 7
Placing	sq. ft. per man, hour, 10

OBSTACLE CONSTRUCTION (Material and tools on hand)—

Abattis, wired (1 strong row).....linear feet, 1.5

Wire entanglement—

High	square feet, 27
Low	square feet, 90

By working in two reliefs above figures can be increased by one-third.

CLEARING—

Thickets up to 1.5 inches diameter.....square yards, 25
 Light clearing of soft woods, trees to 12 in. in diameter.....square yards, 25
 Medium clearing.....square yards, 15

Plate 13 shows in outline the general method of laying out and proceeding with the work.

OBSERVATION, TELEPHONE, WATER SUPPLY AND MAGAZINES.

Well concealed and well located observation stations are very necessary for a fortified position. These stations must afford the observer a maximum amount of cover and concealment, consistent with the performance of his duties.

A complete telephone system is necessary so as to afford ready communication with all parts of the fortified position. With a com-

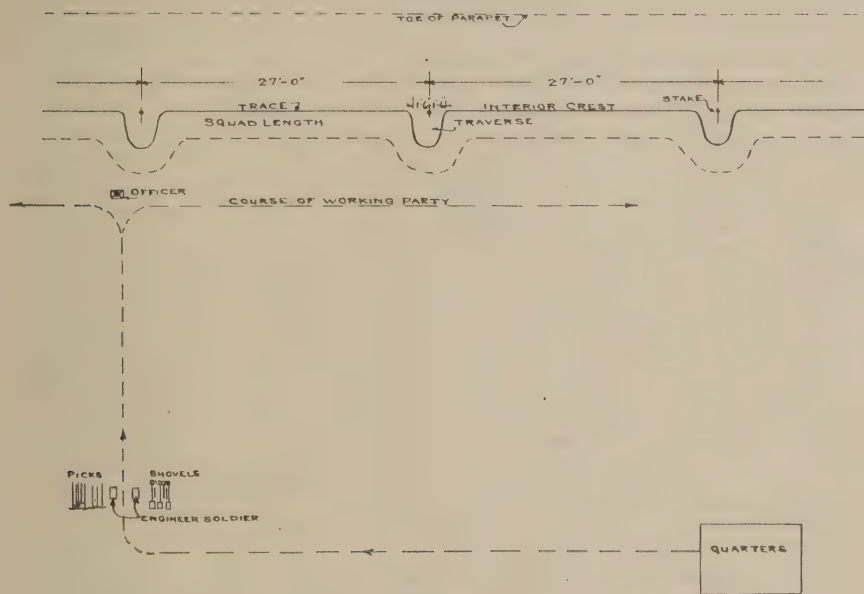


Fig. 13.

plete telephone system, guns of the same batteries can be scattered over considerable area without the loss of fire control.

Good drinking water must be provided for the soldiers who occupy the trenches. Clean water is also a help for the "first aid" of the wounded. The arrangement to be made will depend on the local requirements and conditions.

Special magazines are not necessary. Recesses cut in front wall or cartridge boxes placed at convenient places will generally fulfil the requirements of ammunition storage.

A GERMAN FORTIFIED POSITION.

Major General Mayer proposes the following arrangement of a defensive position: As he considers that observation from aeroplanes may obviate the difficulty of locating the exact position of the defenders' shelter trenches, and he thinks a distinct difference should obtain in the defense against distant fire and against the close attack and assault. He constructs an advanced line of fire trenches for defense against the close attack and 100 meters behind this a second row of cover trenches, connected by approaches with the front line. Both are dug out on the front slope of a hill below the crest, the rear or cover trench being about 200 meters in front of the line of guns just behind the crest. He proposes to have no wire entanglements as obstacles because these would be easily seen and give away the position; but to have land-mines constructed 150 meters in front of the front fire-trenches. Machine gun sections should deliver frontal and oblique fire between the land-mines and the front line of fire-trenches to meet the close attack. Also machine guns for more distant frontal fire effect should be in position behind the line of cover-trenches. Machine guns in pairs should also be placed for flanking fire in or behind the shelter-trench for the close defense. This system cannot be spoken of as multiplying the defensive lines. It is a single line, if you consider that the second trench is simply a line of trenches arranged as a cover-trench for defense from distant fire. The designer pictures to himself the course of the action thus: The airmen have from their great height only been able to observe the ground very generally. The machine guns being easily masked, would remain unnoticed. The guns and rear line of machine guns open fire, say, at 1,500 meters, against the hostile infantry advancing cautiously to the attack. The line of defenders told off for distant fire would only open fire when the attackers reinforce strongly, then they use rapid fire. No shot is fired out of the front fire-trenches until the attackers come within 300 yards. Then the machine guns in the front line open fire and oblige the attackers to bring up field-guns to engage them. The men in the front shelter-trench fire open fire when the attackers are about 150 meters off and the mines have begun to act. This would be the moment for the counter-stroke by the reserve, which has been kept back concealed. The decisive line of defense is thus undiscovered until the decisive moment, which the defender utilizes to repulse the attack.

BRITISH TRENCHES.

The following remarks are extracted from Instructions in Field Training for the British Army. They are based upon the experience of the European War. They are especially applicable to fortifications which are to be occupied for a relatively long time and in relatively close proximity to similar works of the enemy. They are also of special interest as indications of the very great

power of modern weapons and the resulting necessity for concealment from view :

Trenches should be located so that they are not under observation by hostile artillery. Possible observing stations on ground occupied by the enemy should also be considered. This concealment is regarded as of greater importance than an extensive field of fire.

A field of fire of 100 yards will be sufficient if it cannot be extended without loss of concealment. Obstacles in front of the trenches must be carefully concealed, as otherwise they will assist the enemy to locate the trenches in rear.

A location for the trenches back of a slight rise or back of a second hedge with obstacles hidden or entangled in the hedge in front has been found to afford satisfactory concealment.

Modern artillery fire is practically continuous and the accuracy of ranging phenomenal. Accordingly, the target must be reduced to the smallest possible dimensions. This is best accomplished by making the trenches as narrow and as deep as possible with practically no parapet. Support trenches especially should be made deep. The support trenches should be about 40 yards in rear of and parallel to the fire trenches with ample communications to the latter. To these most of the men retire during a bombardment, leaving as few as possible in the fire trenches. Eighteen to twenty-four inches is sufficient width for a trench. As this does not permit of the free passage of men along the trench, communication is secured by means of a narrow trench about 15 yards in rear of the firing trench and connected to the latter at each traverse by a narrow passage of the same depth. (See Plate 14.)

The fire trenches should be of the recessed traversed type whenever time permits, traverses about 5 feet wide at the base and 35 feet center to center. (See Plate 15.)

Surplus earth from the trench excavation should be spread or sodded, depending on the nature of the soil.

A bank of earth as a *parados* should be placed behind and close to the trenches for protection against the back blast of high explosive shells, provided this can be done without rendering the trenches conspicuous. These *parados* should be sodded or otherwise concealed in the same manner as the parapet. Dummy parapets may be constructed with surplus earth.

Recesses under the parapet must be ceiled. If planking or other similar material is available time and trouble may be saved by laying the ceiling for the recesses on the ground at the front of the trench, with a good bearing at the ends, and then excavating the recess and throwing the earth on top of the ceiling to form the inner part of the parapet. The recesses serve to protect their occupants from shrapnel fire.

Elbow rests should be omitted or made very narrow. Most of the men will prefer to make their own niches for the forearm. A

device to ensure proper aiming in the absence of lights during a night attack is desirable.

Head cover and overhead cover are usually impracticable, except at points to be used as observing stations. They restrict the use of the rifle and bayonet. Where head cover can be constructed to advantage a continuous loophole is the best form.

The arrangement of trenches should be such as to develop as much frontal fire as possible. Attacks by the enemy usually occur at frequent intervals at night along the whole line. Under such conditions adjacent sections of the line can give but little support to each other by crossing fire. As cross and flanking fire is not to be relied upon, straight trenches are preferred.

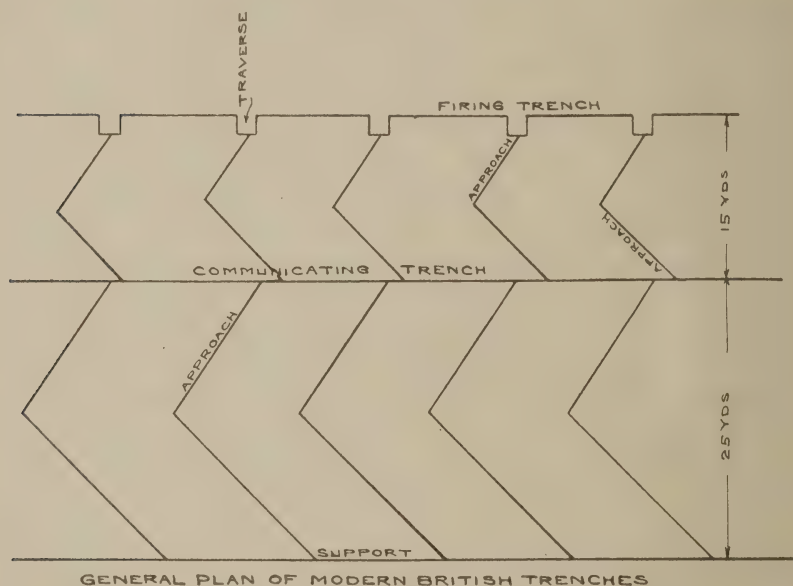


Fig. 14.

Dressing stations and latrine may be provided in recesses in the support trenches.

Drainage should be considered in laying out the trenches. When practicable they should be drained to a low point in the locality. When this is not practicable, sump holes must be provided in the trenches, to be pumped or baled out.

Machine gun emplacement should be on the flanks of a section and as well concealed as possible. They should not be unmasked too soon, as this exposes them to premature destruction by the hostile artillery.

Cover required for the reserves will depend upon their distance in rear of the firing line and the enemy's ability to search with fire

the ground in which the reserves are stationed. The possibility of observation by aerial reconnaissance must always be considered.

Obstacles must be provided to check the enemy's attempts to rush the trenches. Barbed wire is the most effective obstacle, especially if well concealed. The advantage of concealment, in addition to preventing the use of the obstacles as range marks for the trenches in rear, is that working parties are enabled to repair each night any damage to the obstacles. This repair work must frequently be carried out not over 100 yards and occasionally not over 50 yards from the enemy's trenches. High wire entanglements involving the use of posts extending 3 feet 6 inches or 4 feet above the ground are impracticable owing to the difficulty of concealment and of repair. The driving of such posts is out of the question when

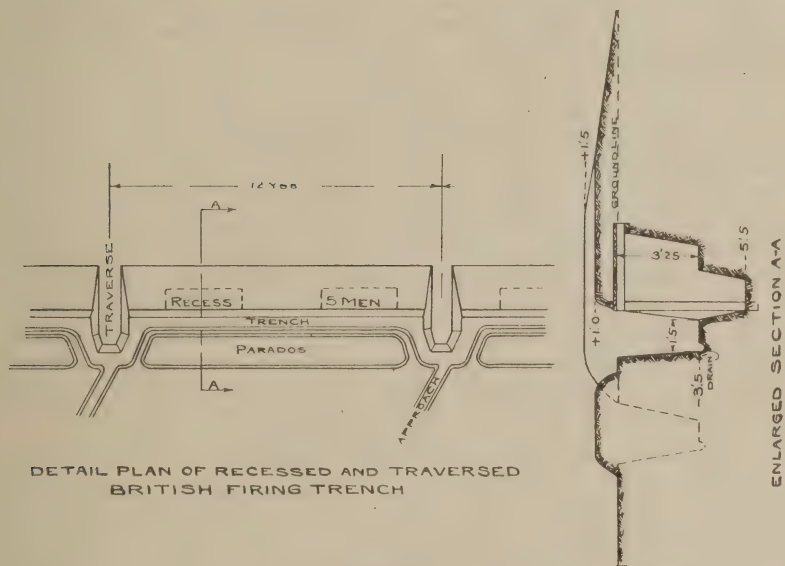


Fig. 15.

hostile trenches are in close proximity. Various substitutes for these posts may be employed, such as tripods, constructed of the limbs of trees lashed together, carried out and set in front of the firing line at night, at intervals of about 15 feet. The tripods are anchored to the ground and barbed wire laced between them. Any light, strong, portable support for barbed wire entanglements is acceptable.

Flare lights shielded on the side of the defender may be employed.

If the flank of a line is refused, the trenches should be echeloned to the rear. Otherwise the trenches on the flank will be subject to enfilade fire, especially by heavy artillery at long ranges.

The following observations of the aeronauts will be of assistance to those engaged in the construction of field fortifications:

1. A long continuous line of trenches is more visible than groups of trenches.

2. Straight trenches are conspicuous.

3. Trenches across plowed fields are easily distinguished.

4. Straw spread in the bottom of trenches renders them conspicuous.

5. Trenches against hedges cannot be distinguishable.

6. It is difficult to tell whether trenches or gun emplacements are occupied.

7. Tracks to emplacements are easily distinguished.

8. Trenches should be covered with brush to hide deep shadows at bottom.

9. The operations on the European battle fields closely resemble the methods which have hitherto been considered characteristic of sieges.

Sir John French says: "In war as it is today, between civilized nations armed to the teeth with the present deadly rifle and machine gun, heavy casualties are absolutely unavoidable. For the slightest undue exposure the heaviest toll is exacted. The power of defense conferred by modern weapons is the main cause for the long duration of the battles of the present day, and it is this fact which mainly accounts for such loss and waste of life. Both one and the other can, however, be shortened and lessened if attacks can be supported by a most efficient and powerful force of artillery available; but an almost unlimited supply of ammunition is necessary, and a most liberal discretionary power as to its use must be given to artillery commanders. I am confident that this is the only means by which great results can be obtained with a minimum of loss."

PERMANENT FORTIFICATION.

The ease with which the Germans successfully captured Liege, Namur, Antwerp, and the camp retranches of Maubeuge, Lille, Laon-La Fere and Rheims, all very strong positions on paper, has proved rather damaging to the prestige of permanent fortifications. Yet there is no case for a wholesale condemnation of forts when circumstances are carefully examined. Both Belgian and French fortresses were sadly out of date in armament as well as in defensive organization, and were crushed at long range by an artillery of superior caliber (280, 305 and 420 millimeters—11.032, 12.017 and 15.548 inches) to which they could make no effective reply. To the admirably handled German heavy ordnance that fired with incredible accuracy at ranges of ten to fourteen kilometers, the French fortress artillery could only oppose, together with obsolete mortars and insufficient field guns, weapons of 155 millimeters (6.107 inches) with a range of little over 8,000 yards.

No attempt was made to defend Lille, Laon and Rheims, totally out of date and not thought to be worth the huge garrisons which

they would have absorbed. Maubeuge alone offered a stout resistance, though perhaps not so long as could have been expected from its new (but under-gunned) forts and from its garrison of 30,000 men, including nine infantry regiments and a few artillery battalions, mostly reservists. That place-forte, besides having no long range cannon, was filled by tens of thousands of helpless Belgian refugees, mostly women and children, which constituted a source of weakness. After a ceaseless night and day bombardment, lasting from August 23 to September 7, in the course of which the garrison did its duty, attacking continuously and inflicting over 20,000 casualties on the enemy (so much was admitted by German officers), the governor, Gen. Fournier, surrendered a town on fire, full of dead and wounded, the forts of which were reduced to heaps of ruins. Only a few thousand men of the garrison succeeded in breaking through the lines of the besiegers.

It is estimated that Maubeuge rendered considerable service in delaying for two weeks the advance of an important portion of the hostile artillery and in preventing the enemy using the most direct railway line from Liege to Paris. The same is true also of the obsolete fortress of Longwy, where 3,000 Frenchmen stopped for twenty-one days part of the Kronprinz's army, winning war honors from the victor, and of the old (1874) fort of Troyon, with a garrison of 470 men, which the enemy was confident of reducing in a few hours, but which resisted an intense bombardment of five days, repulsed three brave attacks of German infantry, and cost nearly 2,000 casualties to the besiegers.

But, of course, reliable information as to the value of fortifications can only be derived from a study of the way modern fortresses have stood the test of war. Now, the camps retranches of Verdun, Toul, Epinal and Belfort are the only ones that deserve at all to be called modern, having been the object of ceaseless improvements in recent years, though at the beginning of the war they were not quite up to date in armament, not having received the long range naval guns that now arm them. And it is a fact that they have up to the present defied the whole might of heavy German guns and the repeated and well-led attacks of the masses of German infantry, especially Verdun, which is yet partly encircled, though at very long distance—over 20,000 yards.

From reliable source we further learn that the excellent resistance offered by the Verdun fortifications is also due to the fact that many of the large guns were removed from their permanent emplacement and were then placed in concealed positions from which they could be readily moved in case the enemy discovered the position.

Several semi-permanent emplacements are provided for each gun.

The small circular fort, with its batteries, powder magazines and garrison quarters crowded over a limited area is a thing of the past. The permanent fortification with mobile and concealed bat-

teries distributed over a large area, and well placed and concealed infantry intrenchment is and will be of great value. This is the opinion of some of our army engineers and some of the foreign military experts.

The author herewith sets forth the requirements and conditions which he believes are necessary to withstand successfully the attack of the present high power weapons: .

1. Superiority of range and armament.
2. Concealment and mobility of armament.
3. Wide area of operation.
4. A cleared area around site of fort.

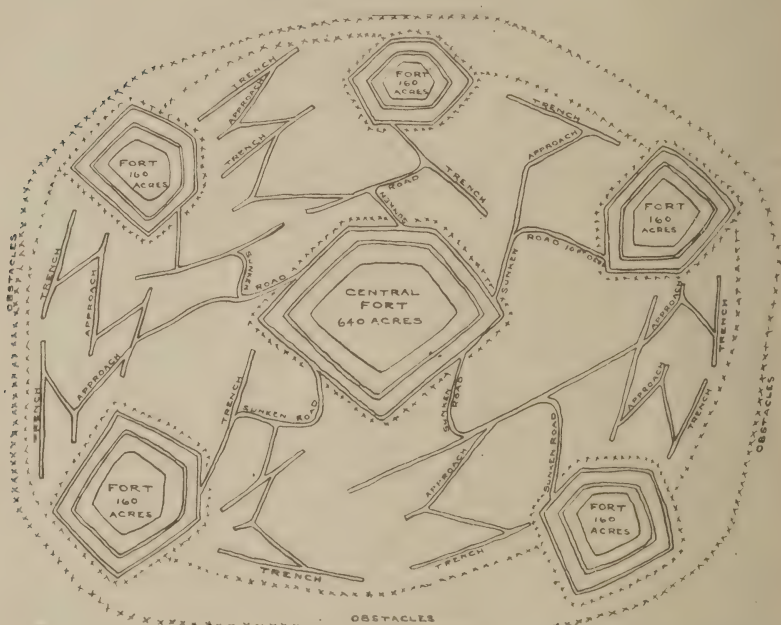


Fig. 16.

Modeled after the sketches of the
fortress of Ossaweltz
taken by Major Robert R. McCormick

5. Well placed and concealed obstacles.
6. New type armored turrets.
7. Dummy turrets.
8. Concealed infantry trenches.
9. Centrally located magazines.
10. Cover for garrison.
11. Covered and concealed communications between the different parts of the fort.
12. A complete telephone and wireless system.
13. A complete lighting system.
14. Ample water supply.

Plates 16 and 17 will give a general idea of the author's plan

of a modern permanent fortification. As to the thickness of cover, lighting system and other exact data and details we must await the further developments of this present war.

SEA-COAST FORTIFICATION.

General Bernard, in one of his reports, outlined the use and purpose of seacoast fortifications as follows:

"Seacoast fortifications must close all important harbors against an enemy and secure them to our commercial and military marine.

"Second, must deprive the enemy of all strong positions, where, protected by naval superiority, he might fix permanent quarters on our territory, maintain himself during the war and keep the whole frontier or coast in perpetual alarm.

"Third, must cover the great cities from attack.

"Fourth, must prevent, as far as practicable, the great avenues of interior navigation from being blockaded at their entrances into the ocean.

"Fifth, must cover the coastwise and interior navigation by closing the harbors and the several inlets from the sea which intersect the lines of communication, and thereby further aid the navy in protecting the navigation of the country.

"Sixth, they must protect the great naval establishments."

Wars of recent years, as well as the present European War, have demonstrated that it is practically impossible to reduce seacoast fortification, if properly defended, by ships' fire, and, when fortified posts have fallen, such a result has been secured by land operation assisted by a blockade. The proper land defense in connection with coast defense is therefore an absolute necessity.

An effective system of coast defense must consist of land batteries, with their protecting guns and searchlights, submarine mines, torpedoes, torpedo and submarine boats, floating defenses, barricades, dams and proper land defenses.

To prevent distant bombardment by a fleet, and also to prevent the forcing of a passage or a running past the defenses, high-power guns are required for disabling or silencing battleships and cruisers at long ranges, and in addition to the mines smaller guns of the rapid-fire type are needed for similar purposes and to repel torpedo-boat attacks at the closer ranges.

Sea-coast fortifications are best protected from the attack from the land side by mobile troops well entrenched and supported by sufficient mobile artillery. The heavy guns and mortars should also be designed so that they can be turned and used in the land defense.

Mines are and should be considered as obstacles and in order to accomplish their object must succeed in holding the enemy in the zone of greatest effective fire. They must allow safe passage of the vessels of the defense but must be instantly dangerous to the enemy's ships.

The United States coast defense is provided with 8-inch, 10-inch, 12-inch and 16-inch caliber guns for heavy armament. The mortars

are mostly of 12-inch caliber. The rapid-fire armament consists of 6-pounders and 15-pounders and 5-inch and 6-inch caliber guns.

The long range guns are usually placed at a height of 165 to 250 feet above sea-level.

The mortars are usually placed at a height of 260 to 300 feet above sea-level.

The lighter and rapid fire guns are usually placed at height of about 60 feet above sea-level.

Three systems of range finding are now in use:

1. The horizontal base system with a horizontal base along shore and which has an observation station at each end of this base. The target is located by the intersection of the lines of sight from the two stations.

2. The vertical base system with the vertical height of instrument above mean low water as the vertical base. The distance to

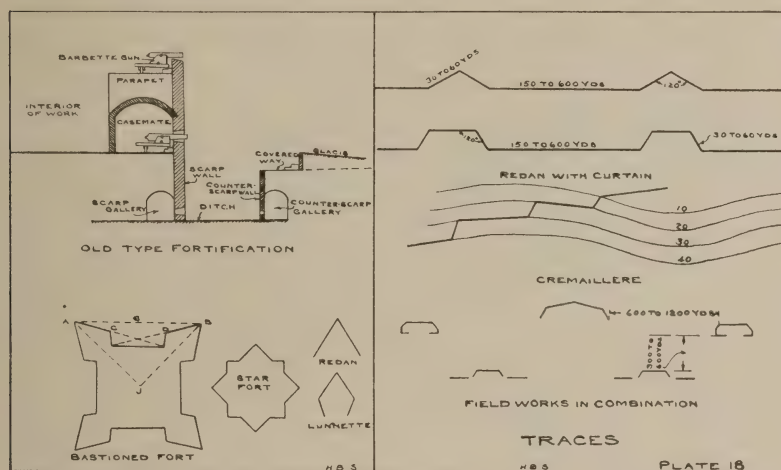


Fig. 18.

the target is read off the instrument in yards directly when the horizontal cross-wires of the telescope is directed on the water line of the target. The azimuth is obtained on the graduated horizontal circle.

3. The third system is the coincidence range-finding system, which requires a single station equipped with a coincidence range finder. This range finder is equipped with an azimuth reading device.

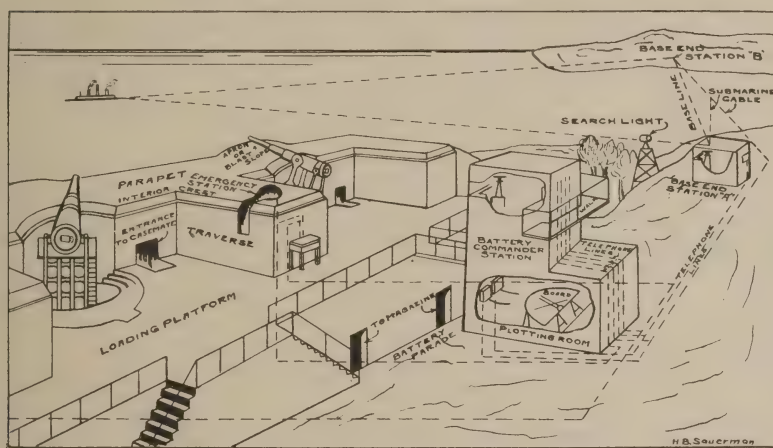
For protection and cover, some of our sea-coast fortifications are provided with 15 feet of concrete and 45 feet of sand for walls exposed to horizontal fire and 10 feet of concrete where exposed to vertical fire.

Mobility and concealment of armament should receive special

small barren and rock-strewn island has been transformed into a formidable defensive work and so well has the work been planned that Germany's entire navy finds absolute protection behind this island, against the attack of the greatest navy that has ever cruised the waters of the world.

To illustrate a modern fortified harbor, the system of the Austrian, Colonel Mielihofer, is reproduced in Plate 19.

The surrounding country of this harbor rises to 60 meters above sea-level, which permits of easy fortification. The inner harbor allows of the location of arsenals and magazines which are entirely covered by the heights, so that these works are not only protected from bombardment by distance, but also by their position. The inner harbor is of sufficient area to accommodate the entire



U. S. COAST-DEFENCE FORTIFICATION

Fig. 20.

fleet. The harbor entrance is quite narrow and easily obstructed, thus making it very easy to defend.

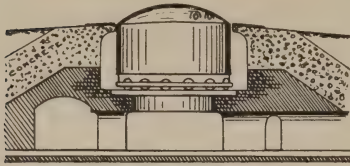
There are two mine fields provided—an outer and an inner. The outer mines surround the entrance proper at a distance of about 2,000 yards and this mine zone is located in the most effective zone of fire of the heavy coast guns. The mines are located and arranged in a double row. The mines nearest to shore are judgment mines, which permit the vessels of the defense to pass over them uninjured, while the others are contact mines.

The inner obstructions consist of a submarine dam at the center of the entrance with passages at each end which are closed by judgment mines. In rear of these mines barricades are placed.

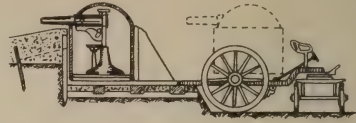
The mine fields and barricades are flanked by rapid fire batteries

and shore torpedo batteries. The field of fire is illuminated by means of searchlights.

Plate 20 shows a typical sea-coast fortification in detail.



THE BELGIAN TURRET FORT
2-5.9 INCH GUNS



THE GERMAN MOVABLE TURRET

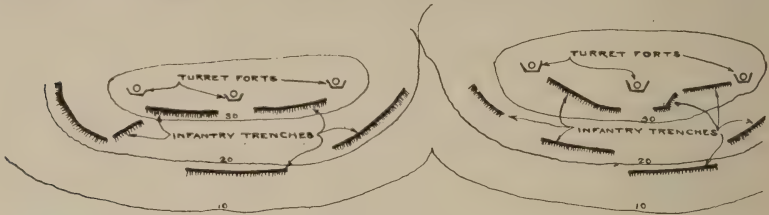


Fig. 21.

Plate No. 21 shows a Belgian steel turret fort; also a German portable turret. These steel turrets are usually placed in combination with trenches as outlined in plan on this plate.

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